(12) UK Patent Application (19) GB (11) 2 065 823 A

(21) Application No 8040249
(22) Date of filing 16 Dec 1980
(30) Priority data
(31) 79/43816
80/23955
(32) 20 Dec 1979
22 Jul 1980
(33) United Kingdom (GB)
(43) Application published
1 Jul 1981
(51) INT CL³
F16L 11/08 // 11/12
(52) Domestic classification
F2P 1A12 1A14 1A18A
1A18B 1A19B 1A25 1A3
1A8 1A9 1B5D 1B7 2A3
2C9C
(56) Documents cited
GB 1506182
GB 1210779
GB 1171122
(58) Field of search
F2P
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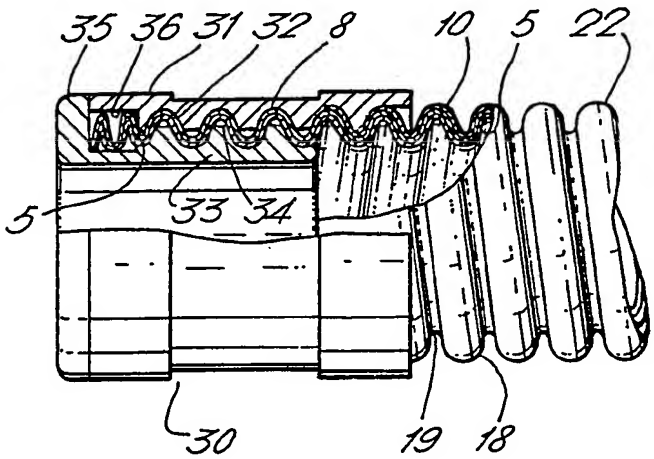
(54) Flexible, multi-layer tubing

(57) Flexible, multi-layer tubing 22 and a method of making same are provided wherein such tubing comprises inner and outer layers 5 and 10 of helically wrapped, polymerised strip material with overlapping convolutions of the respective layers bonded together, by for example heat fusing, and an intermediate layer 8 of helically wrapped metallic strip material. The intermediate metallic layer 8 separates completely the inner and outer layers 5 and 10 and provides a conductive path extending along the tubing.

The multi-layer tubing may be helically corrugated.

Fig.3.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

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Fig.1.

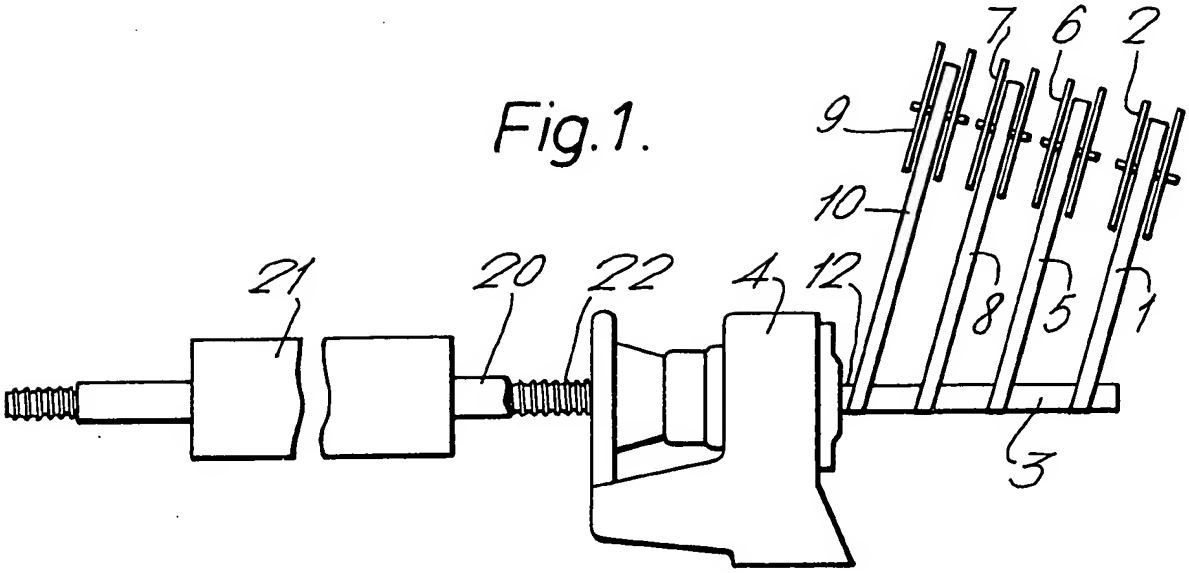

Fig.2.

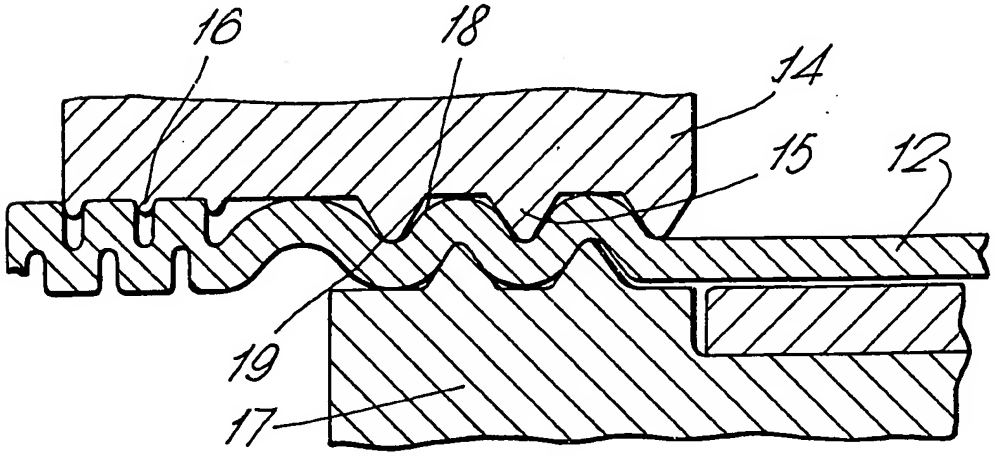

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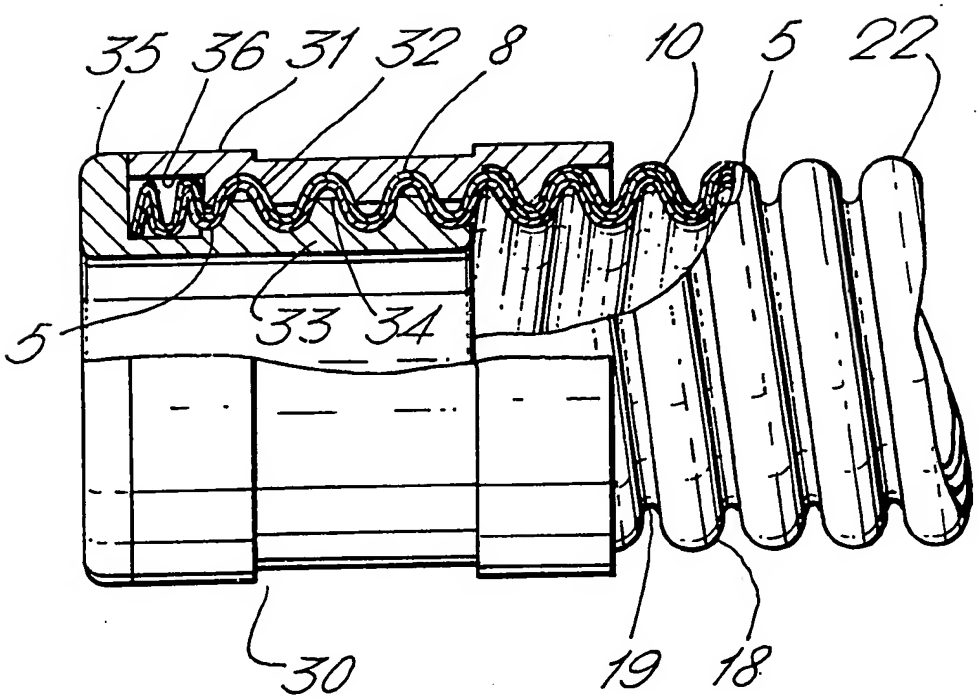
Fig.3.



SPECIFICATION
Flexible tubing

The present invention relates to flexible tubing and to methods of manufacturing flexible tubing.

The invention is especially concerned with flexible tubing with at least one wall of a flexible plastics material and preferably a polymerised organic material such as polytetrafluoroethylene (P.T.F.E.) which is particularly suited to forming tubes in view of its toughness, flexibility and resistance to chemical attack.

In certain applications it is desirable that such flexible tubing be capable of dissipating electrostatic charges originating outside the tubing or screening electrical conductors carried therein. It is one object of the present invention to provide flexible tubing of the aforementioned type which is suitable for these applications.

According to one aspect of the present invention a method manufacturing flexible tubing comprises the steps of helically wrapping flexible, bondable material in strip form upon a mandrel in overlapping convolutions to form a first layer, helically wrapping metallic strip thereupon to form a second layer, helically wrapping flexible, bondable material in strip form in overlapping convolutions upon the second layer to form a third layer, and treating the multi-layer tubing so formed to bond the respective overlapping convolutions of the first and third layers together.

Preferably the flexible materials of the first and third layers are such that their respective overlapping convolutions may be bonded together by the application of heat, and the step of treating the said multi-layer tubing to bond the overlapping convolutions of flexible material together consists of passing the tubing through a hot zone so as to bond the overlapping convolutions and then allowing the tubing to cool.

Preferably the flexible plastics material comprising the third layer is a polymerised, or polymerisable organic substance, e.g. polytetrafluoroethylene (P.T.F.E.).

The flexible material comprising the first layer may also comprise a polymerised, or polymerisable, organic substance, e.g. P.T.F.E. and may be reinforced with, for example glass fibre.

Preferably, the second layer is helically wrapped over the first layer to form overlapping convolutions, and may comprise aluminium.

Preferably the said multi-layer tubing is helically corrugated, with one or more helical ribs and grooves, prior to the treatment to bond the respective overlapping convolutions of the first and third layers.

A strip material, for example, of aluminium may be helically wrapped upon the mandrel in overlapping convolutions prior to the said wrapping of the first layer thereon to provide an inner supporting layer. This layer is adapted to support the first layer until the treatment of the tubing to bond the overlapping convolutions of the first and third layers thereof is completed and is thereafter removed.

Similarly, further strip material may be helically wrapped around the said third layer to provide support for the third layer during the said treatment.

According to another aspect of the present invention, there is provided flexible tubing comprising a first, inner layer, a second, intermediate layer and a third, outer layer, wherein said first and third layers comprise helically wound strips of flexible, bondable material with respective overlapping convolutions being bonded together, and wherein said second layer comprises helically wound metallic material.

The first and third layers may comprise P.T.F.E. and may be reinforced with glass fibre.

The second layer, which may be of aluminium, preferably is continuous and separates completely the first and third layers. The second layer may be helically wound from metallic material in strip form, and, in this case, the adjacent convolutions of the second layer may overlap one another or, alternatively, may abut one another edge to edge.

Preferably the tubing is helically corrugated.

Flexible tubing and their methods of manufacture in accordance with the present invention will now be described, by way of example, with reference to the accompanying drawings of which:—

Figure 1 is a part-sectional side view of apparatus for manufacturing the tubing;

Figure 2 is an enlarged cross-sectional view of part of the apparatus for Figure 1 for helically corrugating the tubing; and

Figure 3 is a part sectional view of the manufactured tubing assembled on an end fitting.

The flexible tubing may be used for conveying fluids or carrying electrical conductors and generally comprises inner and outer continuous layers of P.T.F.E. and an intermediate metallic layer which separates the inner and outer layers and which serves for example both as a screen and as a continuous conductor to dissipate electro-static charges in the tubing.

Referring to Figure 1, aluminium foil strip 1 from a reel 2 is wrapped onto a stationary mandrel 3, the reel being carried by a rotating head (not shown) which causes it to rotate about the axis of the mandrel 3. The wrapped aluminium strip 1 is drawn (without rotation) into a rotating ribbing and grooving tool (indicated at 4) at a speed such that successive convolutions of the strip overlap. The layer of aluminium strip 1 is covered by a strip of glass-fibre cloth material impregnated with P.T.F.E. 5 which is wrapped on to it in similar fashion with successive convolutions overlapping from a reel 6 which is also carried by the rotating head.

A further layer of aluminium foil strip 8 is similarly wrapped onto the P.T.F.E. impregnated glass-fibre layer with successive convolutions overlapping from a reel 7 which is also carried by the rotating head.

Finally, a layer of a P.T.F.E. strip 10 is wrapped around the aluminium layer 8 in a similar manner, again with adjacent convolutions overlapping.

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from a reel 9 carried by the rotating head.

The extent of overlap between respective adjacent convolutions of the layers 1, 5, 8 and 10 may be varied from approximately five per cent to approximately seventy per cent of the width of the strips employed to suit particular requirements.

The four-layer straight walled tube 12 so formed is drawn into tool 4 which, as shown in Figure 2, comprises a rotating threaded die 14 having a first region 15 with a relatively coarse thread and a second region 16 with a finer thread, and a rotating tap 17, co-axial with the die 14 and the mandrel 3. The tap 17 has threads which correspond in pitch to those of region 15 of die 14. It is rotated (by means not shown) so that its position remains fixed in relation to the die 14 with its threads aligned with the grooves between the threads of region 15.

The action of the tap 17 and region 15 of the die 14 helically corrugates the tube 12 and, more specifically, provides the tube with helical ribs 18 and grooves 19. The ribbed tube passes to region 16 of the die 14 where in view of the finer pitch of the threads in that region, the ribs 18 are compressed together reducing the width of the grooves 19. The tube is in this way provided with helical ribs and grooves of very much finer pitch than that of the strips constituting the helically wrapped layers.

The helically-corrugated tube, generally referenced at 22, is then passed through a refractory tube 20 in a furnace 21.

The temperature and time of heating are adjusted so that the overlapping convolutions of the respective P.T.F.E. layers 5 and 10 are bonded together by sintering or fusing to form a continuous-walled and impervious tube. When the tube 22 has cooled lengths of it are cut off as required. The layer 1 of aluminium foil strip is then removed by, for example, deforming the tube 22 to loosen the aluminium layer 1 which can then be readily withdrawn from the bore of the tube 22.

The flexible tube thus formed and comprising layers 5, 8 and 10 may be washed and dried, and either used as it stands or subjected to further manufacturing operations, such as braiding with wire to provide an appropriate degree of mechanical protection.

The inner aluminium layer 1, besides serving to protect the P.T.F.E. impregnated glass fibre cloth layer 5 when the tube passes through the corrugating tool 4, is intended to provide mechanical support for the layer 5 during the heating operation. It has been found however that the provision of this supporting layer is not always necessary as the glass fibre material of the layer 5 can provide sufficient inherent support for the layer to prevent that layer from, for example, collapsing inwardly during the heat treatment, in which case the step of helically wrapping the aluminium layer 1 around the mandrel 3 may be omitted from the above described method.

A further metallic strip, for example of aluminium foil, may be helically wrapped in overlapping convolutions around the P.T.F.E. layer 10 of the tubing, using an additional reel carried by the rotating head, prior to the tubing being drawn into the tool 4 and heat treated to protect and further support the layer 10 during the corrugating and heating operations, the layer being removed from the tubing following the heating operation by peeling. Again however, it has been found that such a supporting layer is in some cases unnecessary.

The flexible tubing formed as described comprises inner and outer layer 5 and 10 of P.T.F.E. and an intermediate layer 8 of aluminium which is continuous and completely separates the inner and outer P.T.F.E. layers. The aluminium layer 8 provides an electrically conductive path extending the length of the tubing which, for example, serves to dissipate electrostatic charges and the like originating outside the tubing and also acts as a screen for electrical cables which may be carried in the tubing.

Although the layer 8 described is constituted by overlapping convolutions of aluminium strip, it is envisaged that the strip may be helically wrapped around the mandrel 3 and over the layer 5 such that the edges of successive convolutions abut one another.

The provision of glass fibre cloth in the inner P.T.F.E. layer 5 considerably enhances the strength of the flexible tubing. However, a strip comprising solely P.T.F.E., similar to strip 10, may be employed instead to form the inner layer 5.

The thickness of the layers 5, 8 and 10 of the flexible tubing is determined by the thickness of the respective strips of glass fibre cloth impregnated with P.T.F.E., aluminium and P.T.F.E. employed and the extent of overlap between successive convolutions of those strips. Thus the thickness of the various layers of the flexible tubing can be controlled by appropriate selection of the thickness of the strips employed. However it is envisaged that more than one strip may be used to constitute each of the layers 5, 8 and 10 by either providing additional reels of strips carried by the rotating head or by feeding two or more strips simultaneously from one reel. For example, if the thickness of the P.T.F.E. impregnated glass fibre cloth layer 5 is to be increased, two strips of P.T.F.E. impregnated glass fibre cloth may be helically wrapped over the aluminium layer 1 (if provided) from the reel 6, or from two separate reels, which would then be fused together during the heating operating to constitute a single layer 5. Similarly, more than one strip of P.T.F.E. may be used to constitute the layer 10.

In alternative embodiments of the invention, it is envisaged that the material comprising the strips 5 and 10 may be reversed so that the strips 5 and 10, and the respective layers of the flexible, multi-layer tubing produced thereby, comprise P.T.F.E. and glass fibre cloth impregnated with P.T.F.E. respectively, or that both the layers 5 and 10 may comprise glass fibre cloth impregnated with P.T.F.E.

Referring now to Figure 3, there is shown, partly in cross-section, flexible tubing

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manufactured in accordance with the methods described above mounted on an end fitting, generally indicated at 30, which provides electrical engagement with the aluminium screening layer 8 of the tubing. To this end, the outer layer 10 of the helically corrugated tubing is removed from the end portion of the tubing to expose the aluminium layer 8. Thereafter, a cylindrical metal sleeve 31 having a helical groove 32 on its internal surface defining a thread whose pitch and width substantially corresponds with that of the helical rib 18 of the tubing is screwed over the tubing with its thread cooperating with the helical corrugation of the tubing until the end two or three corrugations of the tubing project out of the sleeve 31.

A generally cylindrical insert 33 which may be of P.T.F.E. or aluminium and having a helical rib 34 on its external surface whose pitch substantially corresponds with that of the groove 19 of the tubing, is screwed into the bore of the tubing and urges the aluminium layer 8 of the tubing into tight engagement with the cylindrical sleeve 31 to ensure satisfactory electrical contact between the layer 8 and the sleeve 31. The insert 33 is screwed into the bore of the tubing until an annular flange 35 at the end of the insert 33 abuts the end of the sleeve 31. In so doing, the end two or three corrugations of the tubing are compressed by the flange 35 in an annular recess 36 defined between the sleeve 31 and the insert 33. These compressed convolutions serve to inhibit withdrawal of the tubing from the end fitting 30.

As shown in Figure 3, the layer 10 of the flexible tubing 22 is removed along a predetermined length of the end portion of the tubing such that it terminates slightly beyond the end of the insert 33 but still lies within the groove 32 of the sleeve 31.

A cylindrical metal band (not shown) having an upstanding lug may be clamped around the sleeve 31, and the lug attached to a support member both to support the end fitting, and therefore the tubing, and to provide electrical interconnection between the support member and the layer 8 of the tubing. Alternatively, a lug may be directly welded on to the sleeve 31 and used to secure and earth the end fitting 30 on a support.

Although flexible tubing and method of manufacturing flexible tubing have been described above with reference to the use of P.T.F.E. for forming the layers 5 to 10, other flexible materials, and in particular polymerised, or polymerisable, organic materials, may be used instead. For example, the layer 10 of the flexible tubing may comprise polyvinylchloride (P.V.C.), and the layer 5 glass fibre cloth impregnated with P.V.C.

Similarly, other metal foils can be used for the layer 8 in addition to aluminium, and the layer 1, if provided, may be formed from any material which can provide additional support for the layer 5 during heat treatment and which can readily be removed from the tubing thereafter should such additional support be necessary.

CLAIMS

1. A method of manufacturing flexible tubing comprising the steps of helically wrapping flexible, bondable material in strip form upon a mandrel in overlapping convolutions to form a first layer, helically wrapping metallic strip thereupon to form a second layer, helically wrapping flexible, bondable material in strip form in overlapping convolutions upon the second layer to form a third layer, and treating the multi-layer tubing so formed to bond the respective overlapping convolutions of the first and third layers together.

2. A method of manufacturing flexible tubing according to Claim 1, wherein the overlapping convolutions of the first and third layers comprise a heat-bondable material, and wherein the step of treating the said multi-layer tubing to bond the respective overlapping convolutions of the first and third layers together comprises passing the tubing through a hot zone so as to bond the overlapping convolutions and thereafter allowing the tubing to cool.

3. A method of manufacturing flexible tubing according to Claim 1 or 2, wherein the flexible bondable material of the third layer is a polymerised or polymerisable organic material.

4. A method of manufacturing flexible tubing according to Claim 3, wherein the said third layer comprises a polymerised or polymerisable organic material reinforced with glass fibre.

5. A method of manufacturing flexible tubing according to Claim 3, or Claim 4, wherein the said third layer comprises polytetrafluoroethylene.

6. A method of manufacturing flexible tubing according to any one of Claims 1 to 5, wherein the flexible material of the first layer comprises a polymerised or polymerisable organic material.

7. A method of manufacturing flexible tubing according to Claim 6, wherein the said first layer comprises a polymerised or polymerisable organic material reinforced with glass fibre.

8. A method of manufacturing flexible tubing according to Claim 6 or Claim 7, wherein the said polymerised or polymerisable organic material of the first layer comprises polytetrafluoroethylene.

9. A method of manufacturing flexible tubing according to any one of the preceding claims, wherein the metallic strip is helically wrapped upon the first layer in overlapping convolutions.

10. A method of manufacturing flexible tubing according to any one of Claims 1 to 8, wherein the metallic strip is helically wrapped upon the first layer such that the edges of successive convolutions abut one another.

11. A method of manufacturing flexible tubing according to any one of the preceding Claims, wherein the said metallic strip constituting the second layer comprises aluminium.

12. A method of manufacturing flexible tubing according to any one of the preceding claims, including the step of helically corrugating the multi-layer tubing.

13. A method of manufacturing flexible tubing according to Claim 12, wherein the multi-layer tubing is helically corrugated prior to the step of

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treating the tubing to bond the respective overlapping convolutions of the first and third layers.

14. A method of manufacturing flexible tubing according to any one of the preceding claims, including the steps of helically wrapping strip material upon the mandrel prior to the said first layer being wrapped thereupon to provide a supporting layer for supporting the multi-layer tubing during the said step of treating the tubing, and thereafter removing the supporting layer.

15. A method of manufacturing flexible tubing according to any one of the preceding claims, including the steps of helically wrapping strip material around the third layer of the multi-layer tubing prior to the said step of treating the tubing to provide support for the said tubing during the treating step, and thereafter removing the strip from around the third layer.

16. A method of manufacturing flexible tubing substantially as hereinbefore described with reference to Figures 1, 2 and 3 of the accompanying drawings.

17. Flexible tubing comprising a first, inner layer, a second, intermediate layer and a third, outer layer, wherein said first and third layers comprise helically wound strips of flexible, bondable material with respective overlapping convolutions being bonded together, and wherein said second layer comprises helically wound metallic material.

18. Flexible tubing according to Claim 17, wherein the said third layer comprises a polymerised organic material.

19. Flexible tubing according to Claim 18, wherein the said third layer comprises polytetrafluoroethylene.

20. Flexible tubing according to Claim 18 or Claim 19, wherein the said thid layer includes glass fibre.

21. Flexible tubing according to any one of the Claims 17 to 20, wherein the said first layer comprises a polymerised organic material.

22. Flexible tubing according to Claim 21, wherein the said first layer comprises polytetrafluoroethylene.

23. Flexible tubing according to Claim 21 or Claim 22, wherein the said first layer includes glass fibre.

24. Flexible tubing according to any one of Claim 17 to 23, wherein the said second, intermediate layer is continuous and separates completely the said first and third layers.

25. Flexible tubing according to Claim 24, wherein the edges of adjacent convolutions of the helically wound second layer abut one another.

26. Flexible tubing according to Claim 24, wherein the said second layer is helically wound in overlapping convolutions.

27. Flexible tubing according to any one of Claims 17 to 26, wherein said second layer comprises aluminium.

28. Flexible tubing according to any one of Claims 17 to 27, wherein the tubing is helically corrugated.

29. Flexible tubing substantially as hereinbefore described with reference to Figures 1, 2 and 3 of the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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